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Twenty-five year trends in prevalence of chronic bronchitis and the trends in relation to smoking

Margit K. Pelkonen [a,*], Irma-Leena K. Notkola [b], Tiina K. Laatikainen [c,d], Heikki O. Koskela [a]

[a] Department of Pulmonary Diseases, Kuopio University Hospital, Kuopio, Finland
[b] Finnish Information Centre for Register Research, Helsinki, Finland
[c] Institute for Health and Welfare, Helsinki, Finland
[d] Institute for Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio, Finland

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KEYWORDS
Chronic bronchitis;
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Summary
Introduction: The present study examines how the trends in the prevalence of chronic bronchitis during the last three decades associate with changes in smoking habits during the same period.
Methods: Altogether 47 896 subjects aged 25–74 years were examined in six independent cross-sectional population surveys repeated every five years between 1982 and 2007 in Finland. The presence of chronic bronchitis, smoking habits and other risk factors were measured by standard questionnaires.
Results: During the study, the prevalence of chronic bronchitis was significantly higher in men than in women. In men aged 25–64 years, the prevalence of chronic bronchitis decreased from 19% in 1982 to 13% in 2007 (p for trend <0.001). The corresponding decrease in women aged 25–64 years was from 13% to 11% (p for trend 0.009). In men aged 65–74 years, the prevalence of chronic bronchitis decreased from 24% to 19% (p for trend 0.032). Simultaneously, male smoking decreased and smoking in middle-aged women increased. However, adjusting for the changes in smoking habits did not change the declining trends in the prevalence of chronic bronchitis. The significant declining trend in chronic bronchitis was seen separately in male current smokers and in male and female never smokers aged 45–74 years and the declining trend was the greatest in male current smokers. In general, female smokers with chronic bronchitis had smoked less than their male counterparts.

* Corresponding author. Department of Pulmonary Diseases, Kuopio University Hospital, Po Box 100, FI-70029 Kuopio, Finland. Tel.: +358 17 172669; fax: +358 17 172683.
E-mail address: Margit.Pelkonen@kuh.fi (M.K. Pelkonen).

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Conclusion: There was a declining trend in the prevalence of chronic bronchitis which was probably explained by both a decrease in smoking and by other factors.

Introduction

Chronic bronchitis is characterized by chronic mucus secretion from airways and smoking plays an important role in its pathogenesis [1]. Exposures to occupational airborne particles as well as ageing may also contribute to chronic bronchitis [2,3]. Chronic bronchitis, in turn, has been associated with an accelerated decline in FEV_1 [4,5], with lower life quality [6], increased medical costs [7] and finally with increased respiratory, cardiovascular and all cause mortality [4,8–11].

According to the earlier studies from the United States (the Tecumseh study) and Scotland (the Renfrew and Paisley survey) the prevalence of *chronic phlegm production (most mornings for 3 months/year)* was in 1960s–1970s about 27–28% in general male population aged 40–64 years [9]. In elderly smoking rural Finnish men and women (with mean age 59 and 56, respectively), the prevalence of chronic phlegm production was 41% and 21%, respectively in 1971 [12]. In 1972–77 the prevalence of chronic bronchitis was 22% and 12%, respectively in general Finnish male and female population aged 30–64 years [13]. In the 1980s in Italy altogether 18% and 5% of men and women aged 20–64 years, respectively, reported to have *chronic phlegm production* and the prevalence increased with age and smoking [3]. In 1995, the prevalence of chronic productive cough in northern Finland was 12% in men (10% in women) aged 20–69 years (and 19% in men aged 60–69 years) [14]. Since the beginning of 1970s many tobacco control initiatives have been carried out in Finland and male smoking has declined remarkably since 1972 [15]. On the other hand, Finnish women, like women in many western countries, increased their smoking in the 1970s [15–17]. The present study examines the trends in the prevalence of chronic bronchitis between 1982 and 2007 and their relation to changes in smoking habits in Finland.

Methods

Subjects

Cross-sectional risk factor surveys were conducted every fifth year in Finland by the National Public Health Institute since 1972 [15,18]. Independent population samples were studied in five areas: in the provinces of North Karelia and Kuopio since 1972, in south-western Finland since 1982, in cities of Helsinki and Vantaa since 1992, in Oulu since 1997 and in Lapland since 2002. The study subjects were drawn from the population register by random sampling and the target population was 25–64 year old subjects. The study samples were stratified according to sex and 10-year age group so that at least 250 people (at least 200 in 2007) were included in each subgroup. The sampling method was modified to comply with the protocol of the World Health Organisation MONICA (Multinational Monitoring of trends and determinants in Cardiovascular disease) project [19] and since 2002 the later recommendations of the European Health Risk Monitoring project (EHRM) [20]. Actually, the National FINRISK Studies (1982–1992) were part of the WHO MONICA project and since 1982 also part of the WHO CINDI (Countrywide Integration Noncommunicable Diseases Intervention) program [15]. There was also a sample of subjects aged 65–74 years in the province of North Karelia and Helsinki since 1997 and in Lapland since 2002.

The present study includes six surveys of these National FINRISK Studies, i.e. surveys carried out between 1982 and 2007 ($n = 47\,896$) (Table 1). In the present study, both those smokers who had no complete data on smoking and those smokers who had quit smoking less than a month ago were excluded from analyses (altogether $n = 903$ between 1982 and 2007). Those subjects who had no data on the symptoms of chronic bronchitis ($n = 1540$) and subjects who reported of having asthma diagnosed by a doctor ($n = 1727$) (Table 1) were also excluded.

Measurement of chronic bronchitis, smoking status and other variables

Chronic bronchitis was defined in subjects without a history of asthma by a positive response to the same standard question 'Do you bring up phlegm on most days or nights for at least as much as three months each year' [4,9,21] in a self administered questionnaire. Smoking, marital status, education and occupation were also asked with standardised questions. Smoking status was classified into the three categories: never-, ex- and current-smokers (Table 1). Smokers had smoked regularly at least one year (cigarettes, cigars or pipe) and had smoked during the preceding month. Ex-smokers had stopped smoking at least one month before the survey. The pack-year was calculated by multiplying the years of smoking by the daily number of smoked cigarettes and then dividing the product by 20.

Occupation was classified into seven categories: agriculture and dairy farming, factory, mine and construction work, the unemployed, students, housewives, pensioners and office work (or suchlike work, e.g. service activity). The level of education was classified into four categories: an elementary school, a vocational school, an upper secondary school/college and an academic degree. Marital status was classified into four categories: married/cohabitation without marriage, unmarried, divorced and widowed. The area of residence was classified into four categories: North Karelia and Kuopio, south-western Finland, Lapland and Oulu, and the capital area (cities of Helsinki and Vantaa).

Table 1 Description of the study population by the year of examination, smoking status, the presence of chronic bronchitis and self-reported asthma.

The year of examination						
n	1982	1987	1992	1997	2002	2007
Invited	11 395	7932	7927	11 500	13 498	12 000
Examined (men/women)	9347 (4615/4732)	6479 (3109/3370)	6051 (2849/3202)	8446 (4253/4193)	9580 (4482/5098)	7993 (3740/4253)
Non-responders (men/women)	2048 (1212/836)	1453 (853/600)	1876 (1116/760)	3054 (1747/1307)	3918 (2267/1651)	4007 (2260/1747)
Smoking status						
Never smokers	3962	2804	2596	3752	4294	3634
Ex-smokers	2289	1675	1622	2317	2490	2425
Current smokers	2791	1805	1811	2117	2725	1855
Excluded[a]	305	195	22	260	71	79
Chronic bronchitis	1284	785	855	1085	1175	879
A history of asthma (excluded)	144	145	178	385	459	416
Without data of chronic bronchitis/asthma (excluded)	288	529	6	208	238	271

[a] Excluded were subjects without data on smoking or when last smoked and ex-smokers who had quit smoking less than one month ago.

Statistical methods

The area-adjusted age-specific prevalence rates of chronic bronchitis ($n = 21\,099$ and $n = 22\,598$ in men and women, respectively) were calculated from the results of the logistic regression models, which were fitted for each age group and gender separately using the year of examination and the area as independent categorical variables, using the following formula:

$$\text{Adjusted prevalence} = \text{EXP}(\text{Constant} + \text{B}_{\text{i\_}}\text{Year})/1 + \text{EXP}(\text{Constant} + \text{B}_{\text{i\_}}\text{Year}).$$

Changes in smoking habits during the study in five ten-year age groups were examined using χ^2 test.

The age-specific trends in chronic bronchitis and the possible intermediate role of smoking and other covariates were studied by logistic regression analyses. For each group three models were fitted. The first model included the following independent variables: the year of examination as a continuous variable and area as a categorical variable; the second model included additionally smoking status as a categorical variable; the third model included additionally occupation, education and marital status as categorical variables. The trend in the prevalence of chronic bronchitis was further studied by analysing the smoking groups separately by similar modelling (1st and 3rd models). In current smokers, analyses were additionally adjusted for pack-years. Covariance analysis ($n = 11\,067$) was used to examine the trends in mean pack-years in smokers by ten-year age groups. Covariance analysis was also applied to study (age and the year of examination) adjusted mean pack-years by the presence of chronic bronchitis.

Statistical analyses were performed by SPSS 19.0 for Windows.

The study was approved in 2001 by the ethics committee at the National Institute for Health and Welfare in Helsinki.

Results

Between 1982 and 2007 chronic bronchitis was more prevalent in men than in women in all age groups ($p < 0.001$, except in the oldest age group $p = 0.021$) (Fig. 1). In men, the prevalence of chronic bronchitis declined during the follow-up significantly from 21% (95% CI 16–26%) to 15% (95% CI 11–18%), from 28% (95% CI 23–34%) to 14% (95% CI 11–18%) and from 24% (95% CI 19–30%) to 19% (95% CI 15–24%), respectively in subjects aged 45–54, 55–64 and 65–74 years. In women, there was a significantly decreasing trend in the youngest age group (from 10% (95% CI 7–14%) to 7% (95% CI 5–10%)) and in subjects aged 55–64 years (from 16% (95% CI 12–20%) to 11 (95% CI 8–14%)). Altogether the prevalence of chronic bronchitis in men aged 24–64 years decreased from 19% (95% CI 17–21%) to 13% (95% CI 12–15%). The corresponding decrease in women aged 24–64 years was from 13% (95% CI 11–15%) to 11% (95% CI 9–12%).

Between 1982 and 2007 the percentage of current smokers declined and the percentage of never smokers increased significantly (p for trend <0.001) in all other male age groups, except in the oldest (Fig. 2). In women, the percentage of never smokers increased significantly only in subjects aged 25–34 years and the percentage of never smokers decreased clearly in women aged 35–44, 45–54 and 55–64 years of age (p for trend <0.001) (Fig. 2). During the follow-up (Table E1 on the online repository), there was a significant decreasing trend in pack-years in male current smokers aged 25–34, 35–44 and 45–55 years (p for trend <0.001, 0.010 and 0.001, respectively) and in female current smokers aged 35–44 years (p for trend 0.041). In female current smokers aged 45–54 and 55–64 years, there was a significant ($p < 0.001$) increasing trend in pack-years during the follow-up (Table E1).

In men aged ≥45 years and in women aged ≥55 years (Table 2) there was a significant decreasing trend in the area-adjusted prevalence of chronic bronchitis which did

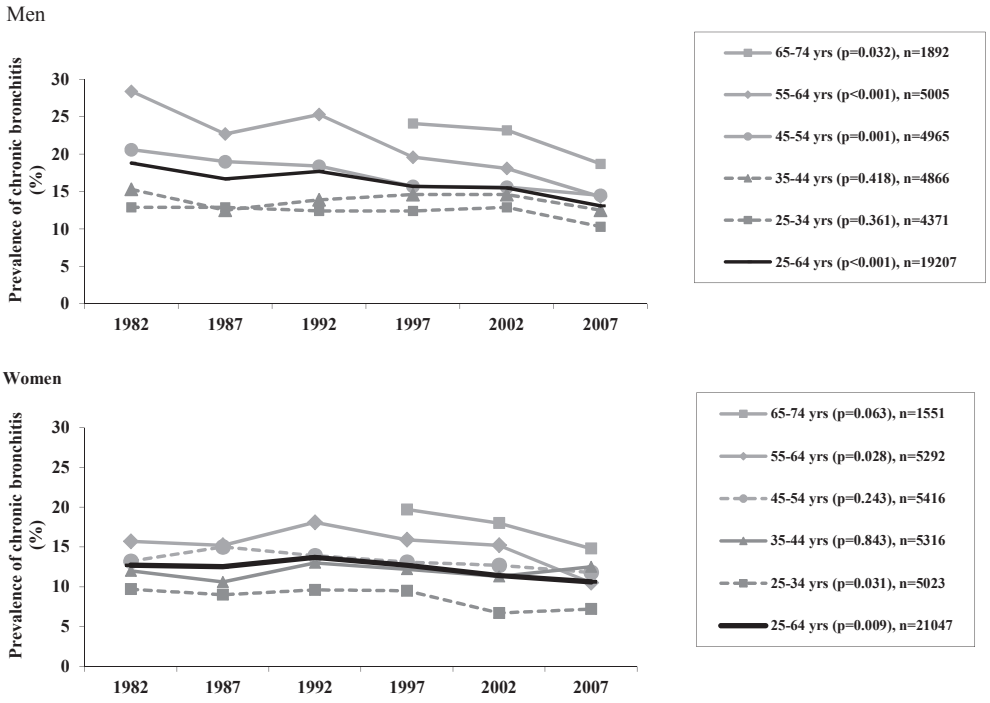

Figure 1 The adjusted prevalence of chronic bronchitis by 10-year age group and the year of examination between 1982 and 2007 in men and women. The 95% confidence intervals are omitted because of clarity. Adjusted for the area of residence. *p* for the trend in parenthesis.

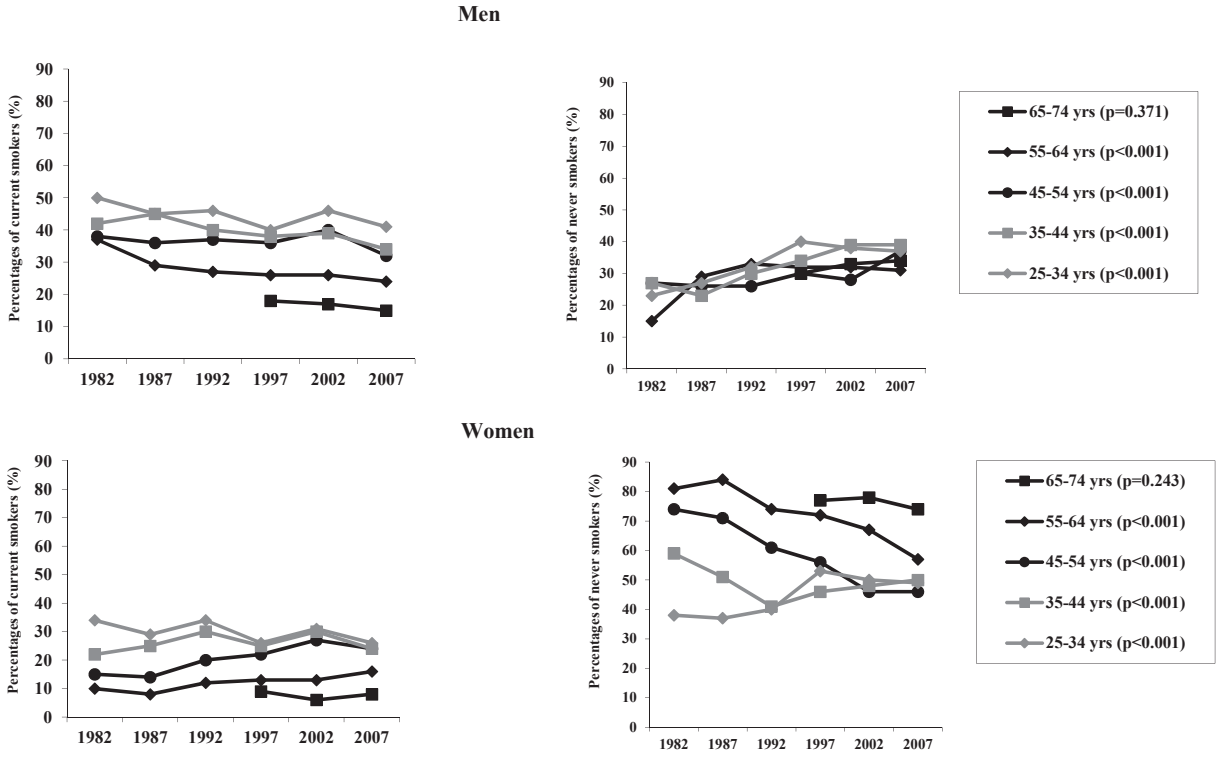

Figure 2 The percentages of current and never smokers by the age group and the year of examination between 1982 and 2007 in men and women. The *p*-values for the trend were calculated by Chi-square-test using the smoking status as a three-category variable (never-, ex- and current-smokers). The number of subjects in each age group the same as in Fig. 1. The percentages of ex-smokers are omitted from Fig. 2 because of clarity.

Table 2 Multivariate adjusted odds ratios (OR) for the trend in chronic bronchitis during 1982–2007 by ten-year age groups.

	n	OR (95% CI)	*p-Value*	OR (95% CI)	*p-Value*	OR (95% CI)	*p-Value*
		Model 1[a]		Model 2[b]		Model 3[c]	
Men							
Age group							
25–34	4320	0.995 (0.983–1.007)	*0.402*	0.998 (0.986–1.011)	*0.801*	1.002 (0.989–1.015)	*0.773*
35–44	4787	0.997 (0.986–1.007)	*0.556*	1.000 (0.989–1.011)	*0.993*	1.002 (0.990–1.013)	*0.795*
45–54	4863	0.983 (0.974–0.993)	*0.001*	0.983 (0.973–0.993)	*0.001*	0.984 (0.974–0.995)	*0.005*
55–64	4894	0.969 (0.960–0.979)	*<0.001*	0.975 (0.965–0.984)	*<0.001*	0.974 (0.964–0.984)	*<0.001*
65–74	1862	0.967 (0.938–0.997)	*0.031*	0.970 (0.940–1.000)	*0.054*	0.972 (0.941–1.003)	*0.077*
Women							
Age group							
25–34	4958	0.987 (0.974–1.000)	*0.046*	0.989 (0.976–1.002)	*0.105*	0.993 (0.979–1.008)	*0.355*
35–44	5231	1.001 (0.990–1.013)	*0.823*	1.000 (0.989–1.012)	*0.962*	1.005 (0.992–1.018)	*0.443*
45–54	5306	0.993 (0.982–1.003)	*0.181*	0.990 (0.979–1.001)	*0.070*	0.998 (0.986–1.010)	*0.724*
55–64	5144	0.988 (0.978–0.998)	*0.018*	0.988 (0.977–0.998)	*0.019*	0.987 (0.976–0.998)	*0.025*
65–74	1524	0.961 (0.926–0.998)	*0.040*	0.958 (0.923–0.995)	*0.027*	0.957 (0.920–0.995)	*0.027*

[a] From a logistic regression model with the following variables: the year of examination and the area of residence.
[b] From a logistic regression model with the following variables: the year of examination, smoking status and the area of residence.
[c] From a logistic regression model with the following variables: the year of examination, smoking status, occupation, education, marital status and the area of residence.

not change significantly after adjusting for smoking habits. The inclusion of the other covariates (occupation, education, marital status) into the model did not have any effect on the results. The decreasing trend was further studied in the subjects aged 45–74 years by dividing subjects into current smokers, ex-smokers and never smokers (Table 3). The decreasing trend in the prevalence of chronic bronchitis was seen in all smoking categories in men (Table 3, Model 1). The inclusion of the other covariates into the model did not change the results in male current and never smokers (Table 3, Model 3). The trend remained significant in male current smokers also after additional adjusting for pack-years (odds ratio (OR) = 0.972 (0.961–0.983), $p < 0.001$) (not shown in Tables). In women, the significant decreasing trend in the prevalence of chronic bronchitis was seen separately only in never smokers (Table 3).

Generally female smokers with chronic bronchitis had smoked less than their male counterparts (on average 16.9 (95% CI 16.0–17.8) and 24.2 (95% CI 23.6–24.8) pack-years, respectively, at the age of 43) (Fig. 3). The interaction between gender and chronic bronchitis was significant ($p = 0.012$) pointing out that the difference in pack-years was less between female smokers with and without chronic bronchitis than in corresponding male smokers.

Discussion

In the present study, there was a declining trend in the prevalence of chronic bronchitis during the last three decades. The adjusted OR for the prevalence of chronic bronchitis in 2007 compared to that in 1982 in subjects aged 45–74 years was in men 0.59 ($=0.979^{25}$ in which 0.979 is

Table 3 Multivariate adjusted odds ratios[a] (OR) for the trend in chronic bronchitis during 1982–2007 by smoking groups in subjects aged 45 to 74.

Smoking status	*n*	OR (95% CI)	*p-Value*	OR (95% CI)	*p-Value*
		Model 1[a]		Model 3[b]	
Men					
All	11 619	0.978 (0.972–0.985)	*<0.001*	0.979 (0.972–0.986)	*<0.001*
Current smokers	3471	0.971 (0.961–0.981)	*<0.001*	0.970 (0.960–0.980)	*<0.001*
Ex-smokers	4756	0.987 (0.975–0.998)	*0.025*	0.990 (0.978–1.003)	*0.127*
Never smokers	3392	0.979 (0.965–0.994)	*0.005*	0.976 (0.961–0.992)	*0.003*
Women					
All	11 974	0.988 (0.981–0.995)	*0.001*	0.992 (0.984–1.000)	*0.039*
Current smokers	1849	0.994 (0.979–1.009)	*0.441*	0.997 (0.981–1.014)	*0.747*
Ex-smokers	2109	0.986 (0.967–1.005)	*0.154*	0.990 (0.970–1.011)	*0.344*
Never smokers	8016	0.987 (0.978–0.995)	*0.003*	0.990 (0.980–1.000)	*0.050*

[a] From a logistic regression model with the following variables: the year of examination, age group and the area of residence.
[b] From a logistic regression model with the following variables: the year of examination, age group, occupation, education, marital status and the area of residence. When all smoking groups are included the analysis was adjusted for smoking status also.

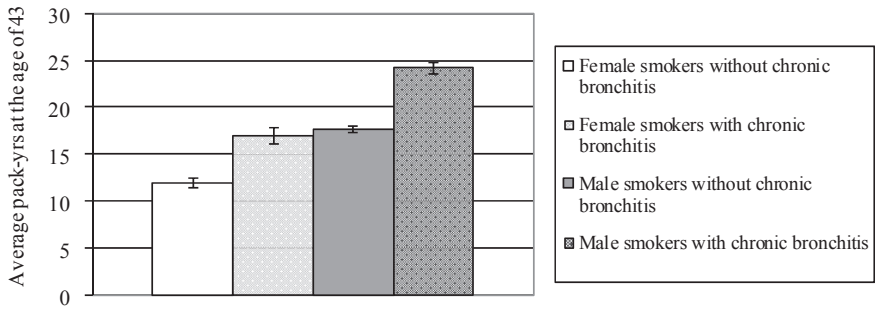

Figure 3 Adjusted average pack-years (95% confidence intervals) at the age of 43 in current smokers by gender and the presence of chronic bronchitis during 1982—2007. From covariance analysis, adjusted for age and the year of examination.

the adjusted OR for a year (Table 3) and 25 is the length of the follow-up) and 0.82 ($=0.992^{25}$) in women. During the follow-up smoking decreased in men and increased in middle-aged women.

Consistently, in a 9-year European follow-up study the prevalence of chronic bronchitis at the end was similar or slightly lower than at the baseline in 1991—93 [22]. The decreasing trends in the prevalence of chronic bronchitis may be mostly explained by the decreasing trends in smoking [23,24]. E.g. in Europe, there has been a decline in smoking among men in all education levels and in more educated women between 1985 and 2000 [23]. In our study, however, only some part of the decreasing trend in chronic bronchitis in men could be explained by changes in smoking habits. In addition, among women, whose smoking rates increased during the study, there was also a decreasing trend in chronic bronchitis. Furthermore, the significant decreasing trend was seen separately in never smokers too. However, in our results there can be left some residual confounding of smoking because we used cross-sectional survey data and smoking habits were asked only once. *In addition, we could not take into account that exposure* to environmental tobacco smoke (ETS) has decreased markedly in Finland from the 1980s' because of legislative smoking restrictions [25], *reinforced later with smoke-free workplace legislation* [26]. The ETS exposure at work has been more common in smokers than in non-smokers, but it has decreased among smokers too *and slightly also at home* [25]. In our study, male smoking decreased during the follow-up likely leading to further decreasing ETS at home. Thus, the decreasing exposure to ETS may explain at least partly the decreasing trend in chronic bronchitis. Accordingly, it has been found earlier that spousal smoking is associated with phlegm production in non-smoking women [27].

The duration of abstinence among ex-smokers in the present study was reported roughly in 1982—92. Generally, *most of ex-smokers (72 %) had quit smoking* $^1/_2$ year — 1 year before the study. Accordingly, in a previous study, a significant decline in respiratory symptoms has been shown already after 12 weeks of abstinence [28]. Unfortunately few our ex-smokers reported how much they had smoked before. Thus, we could not study thoroughly the effects of quitting smoking.

Working in dusty occupations and air pollution has been associated with chronic bronchitis [22,29]. However, in the present study after controlling for smoking, occupation and other variables, the decreasing trend in chronic bronchitis remained significant. *However, our categorization of occupations was rather crude* and though our analyses were adjusted for the occupation this adjustment may not have taken into account all advances in occupational technology during the follow-up. On the other hand, those study subjects who were middle-aged and older in the 1980s had in their childhood and adulthood weaker health care than subjects born in later years (Finland has had a primary health care system based on health centres since 1972 [30]). Also housing conditions have changed, for example in the past the use of wood as a cooking fuel and to heat the houses was more common. Supporting these ideas, chest infections in childhood [10] and biomass burning [31] have been associated with chronic bronchitis. In smokers these factors may have affected more on the development of chronic bronchitis than in non-smokers suggested by the stronger decline in the prevalence in male smokers.

There are some sources of bias which may exaggerate the decline in our prevalence rates. Firstly, the participation rates decreased during the course of the study. In general, in questionnaire studies non-responders tend to be smokers [32] — this does not, however, bias our results, because smoking status was taken into account in analysis. In addition, non-responders have not reported more respiratory symptoms than responders evaluated by a telephone interview [32]. Secondly, during 1982—87 fewer study subjects were excluded because of reporting having asthma than in later years probably resulting from both a real increase in asthma prevalence and increased diagnostic activity [33]. Thus some subjects with asthma may have been misclassified as having chronic bronchitis in the first ten years. Generally, our prevalence rates of chronic bronchitis for men and women aged 24—64 years were in the 1990s at the same level as reported in another Finnish study [34].

Chronic bronchitis has been associated with a risk to develop COPD (chronic obstructive pulmonary disease) [4,5,8] — even in young adults [35]. In the present study, because there were no measurements of pulmonary function, the prevalence of COPD can not be estimated. According to another Finnish study, half of smokers with chronic bronchitis later developed COPD [4]. In one study, subjects with COPD and chronic bronchitis had a greater risk of exacerbations than subjects with COPD without chronic bronchitis [36]. Thus, declining trends in chronic bronchitis might lead to declining trends in COPD, morbidity and mortality [4,8,10]. *In women, increased*

susceptibility to the harmful effects of smoking has been shown earlier [37]. In our study, female smokers with chronic bronchitis had smoked fewer pack-years than their male counterparts. However, there was no significant decreasing trend in chronic bronchitis in female smokers — may be because during the follow-up middle-aged female smokers increased their smoking.

In conclusion, there was a declining trend in chronic bronchitis which could not be explained only by the changes in smoking habits. Possibly, the decrease in exposure to ETS explains the trend at least partly.

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Conflict of interest

No author has any conflict of interest.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.rmed.2014.08.007.

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